HAUBER
ELEKTRONIK

Safety Manual SIL 2

Vibration Monitoring Unit
Series HE200

MADE IN GERMANY | SIL2 | PL-d

IECEE IECEx

c UL us LISTED
Proc. Cont. Eq. for Ord. Loc.
Proc. Cont. Eq. for Haz. Loc.

Segurança
INMETRO UL BR OCP 0029

- ATEX / IECEx / EACEx Zone 2 / 22 and 1 / 21
- cULus OrdLoc / HazLoc Div 2

englisch

Doc ID: M002-HE200 Stand: 2022-02-25

Safety manual

Vibration Monitoring Unit
Type HE200

Standard and ATEX / IECEx / EACEx

Version: 2022-02-25

Attention!
Before putting the product into operation, the safety manual must be read and understood.

Please contact the company with any questions:
HAUBER-Elektronik GmbH
Fabrikstraße 6
D-72622 Nürtingen
Germany
Tel.: +49 (0) 7022 / 21750-0
Fax: +49 (0) 7022 / 21750-50
info@hauber-elektronik.de
www.hauber-elektronik.de

1 Inhaltsverzeichnis

2 Scope of safety manual

This safety manual for the vibration monitoring unit model HE200 applies to variants HE200.00, HE200.02 and HE200.01.
The variants are functionally identical. The HE200.02 and HE200.01 variants also possess certifications and labels which permit use in potentially explosive atmospheres.

3 Fields of application

The HE200 type vibration monitoring unit is used to measure and monitor absolute bearing vibrations in machines in line with DIN ISO 10816. The effective vibration speed value or effective vibration acceleration value is used as the measurement parameter.
The vibration amplitude is then evaluated in two channels independent from each other. If the adjustable vibration threshold value is exceeded, a signal will be sent to the switching contacts. These can be used to generate a pre-alarm and a main alarm. The HE200 type also has an analogue current output. This supplies direct current of 4-20 mA proportional to the vibration amplitude.
The switching contacts and current output were assessed and factored in when determining the safety functionality, using the key indicators related to safety according to the norms mentioned in the section 5.

4 Abbreviations and terms

SIL	Safety Integrity Level
HFT	Hardware Fault Tolerance
SFF	Safe Failure Fraction
CCF	Common Cause Failures
PFD_{avg}	Average Probability of dangerous Failure on Demand
PFH	Probability of a dangerous Failure per Hour
FMEDA	Failure Mode, Effects and Diagnostics Analysis
λ_{sd}	Rate for safe detected failure
λ_{su}	Rate for safe undetected failure
λ_{dd}	Rate for dangerous detected failure
λ_{du}	Rate for dangerous undetected failure
DC_S	Diagnostics Coverage of safe failures; $\mathrm{DC_s} = \lambda_{\mathrm{sd}}/(\lambda_{\mathrm{sd}} + \lambda_{\mathrm{su}})$
DC_D	Diagnostics Coverage of dangerous failures; $\mathrm{DC_D} = \lambda_{\mathrm{dd}}/(\lambda_{\mathrm{dd}} + \lambda_{\mathrm{du}})$
FIT	Failure In Time; $1\ \mathrm{FIT} = 1\ \mathrm{failure}/10\mathrm{h}$
MTBF	Mean Time Between Failure
MTTF	Mean Time To Failure
MTTR	Mean Time To Repair
CAT	Category according to EN ISO 13849-1:2008

Tab. 1: Abbreviations and terms

Other abbreviations and terms are defined in the IEC 61508-4.

5 Relevant norms

IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems. (IEC 61508:2010)
ISO 13849-1 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2015); German version EN ISO 13849-1:2016

6 Safety requirements

Safety integrity level	Operating mode with low requirement rate	Operating mode with high requirement rate
SIL	**PFD_{avg}**	**PFH**
4	$\geq 10^{-5} - < 10^{-4}$	$\geq 10^{-9} - < 10^{-8}$
3	$\geq 10^{-4} - < 10^{-3}$	$\geq 10^{-8} - < 10^{-7}$
2	$\geq 10^{-3} - < 10^{-2}$	$\geq 10^{-7} - < 10^{-6}$
1	$\geq 10^{-2} - < 10^{-1}$	$\geq 10^{-6} - < 10^{-5}$

Tab. 2: Failure threshold values for a safety function, depending on the SIL class (IEC 61508-1, 7.6.2)

Rate of dangerous failures	Fault tolerance of the hardware for type B safety-related subsystems (IEC 61508-2, 7.4.3)		
SFF	**HFT = 0**	**HFT = 1**	**HFT = 2**
< 60%	Not allowed	SIL1	SIL2
60% – < 90%	SIL1	SIL2	SIL3
90% – < 99%	SIL2	SIL3	SIL4
≥ 99%	SIL3	SIL4	-

Tab. 3: Hardware fault tolerance, based on the rate of dangerous failures

The vibration monitoring unit model HE200 is a development in accordance with IEC-IEC-61508. The monitoring was developed as a "high demand system". It corresponds to a 1oo1 architecture with a diagnostic coverage of > 90%. The diagnostics are permanent and automatic during operation and the start-up phase of monitoring. Monitoring fulfils a Safe Failure Fraction of 60%-90% and is thus a sensor system in accordance with SIL2.

7 Project planning

7.1 Safety functionality

The system includes 3 safety functions:

1. If the measured vibration value exceeds the threshold value set for the pre-alarm for longer than the set delay period, the pre-alarm relay will open (pin 5 and pin 6).
2. If the measured vibration value exceeds the threshold value set for the main alarm for longer than the set delay period, the main alarm relay will open (pin 7 and pin 8).
3. The analogue current output depicts the vibration value measured in the interval between 4mA and 20mA.

   The vibration value is either the vibration speed or the vibration acceleration depending on the sensor version.

NOTE

The next control unit must trigger the shutdown should the current output deliver more than 20 mA.

7.2 Fail Safe State

In the event of a fault that cannot be corrected (e.g. hardware defect, or vibration in resonance with the sensor), the sensor will switch to the fail safe state. This state can only be exited by power cycling. The fail safe state can be recognised when all 3 of the following occur at the same time:

– All status LEDs are switched (red, yellow, green)
– All switching contacts are opened. (low level)
– Current output is set to 0mA.

7.3 Configuration safe state

The operator can set the sensor in configuration mode as described in the operating manual. A sensor in configuration mode is not considered to be in a safe state. The safety functions as specified will not operate until configuration has been saved and the sensor is in normal operating mode. The measurement signal is only validated again after leaving the Configuration Safe mode and meets the requirements for the safety function.

7.4 Description of failure categories

The following definitions for failure of the device were considered in order to assess the failure behaviour of the vibration monitoring unit:

– Fail-Safe State
  Responds to a failure state by switching to a safe state. (fail safe state)
– Safe Failure (λsd + λsu)
  A safe failure (S) occurs when the measuring system switches to the defined safe state or to error mode without requesting the process.
– Dangerous Failure (λdd + λdu)
  A dangerous failure (D) generally occurs when the measuring system switches to a dangerous or non-functional state.
– Dangerous Detected Failure (λdd)
  A dangerous detected failure occurs when the measuring system switches to a defined safe state or to error mode when a process is requested.

– Dangerous Undetected Failure (λdu):
  A dangerous undetected failure occurs when the measuring system switches to neither a defined safe state nor to error mode when a process is requested.
– Definition of error mode:
  Error mode is the equivalent to alarm operating mode for the switching contacts.

8 Fault exclusions

1. According to ISO 13849-2 (Table D.7), the multi-pole plug connection was chosen to exclude a short circuit between any two adjacent plug pins.

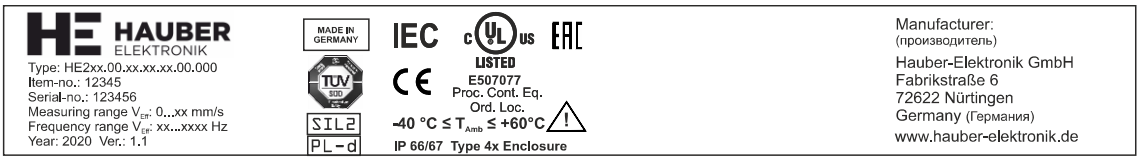
9 Overview of application areas

Coding		HE200.00.xx.xx.xx.00.xxx	HE200.00.xx.xx.xx.01.xxx	HE200.02.xx.xx.xx.00.xxx	HE200.02.xx.xx.xx.01.xxx	HE200.01.xx.xx.xx.00.xxx	HE200.01.xx.xx.xx.02.xxx
Connection	M12 connector	x		x			
	Integrated cable		x		x	x	x
Measuring head temperature T_M Ambient temperature T_A	-40 °C ≤ T_M ≤ 85 °C -40 °C ≤ T_A ≤ 60 °C	x		x		x	
Restriction for the range of application cULus: -30 °C ≤ T_M ≤ 80 °C -30 °C ≤ T_A ≤ 60 °C	-35 °C ≤ T_M ≤ 125 °C -35 °C ≤ T_A ≤ 60 °C		x		x		
	-20 °C ≤ T_M ≤ 125 °C -20 °C ≤ T_A ≤ 60 °C						x

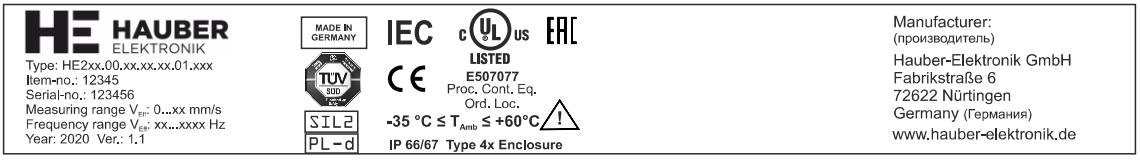
Standard	CE IEC EAC			x	x	x	x	x	x
	c UL us LISTED	Proc. Cont. Eq. Ord. Loc	E507077	x	x	x	x		
Ex Zone 2 and 22	Ex	II 3G Ex ec IIC T4 Gc II 3D Ex tc IIIC 135°C Dc	UL 21 ATEX 2570 X			x	x		
	IECEx	Ex ec IIC T4 Gc Ex tc IIIC 135°C Dc	IECEx ULD 20.0022 Issue 0X			x	x		
	c UL us LISTED	Proc. Cont. Eq. Haz. Loc. Class I, Division 2, Groups A, B, C and D, T4 Class II, Division 2 Groups F and G, T4	E516625			x	x		
	EAC Ex	? ?	? ?			x	x		
	Segurança INMETRO UL BR	Ex ec IIC T4 Gc Ex tc IIIC 135°C Dc	UL-BR 21.1250X			x	x		
	CCC	Ex nA IIC T4 Gc Ex tD A22 IP66/67 T135°C	No: 2021122315114599			x	x		
Ex Zone 1 and 21	Ex	II 2G Ex db IIC T4 Gb II 2D Ex tb IIIC 135°C Db	UL 20 ATEX 2421 X					x	x
	IECEx	Ex db IIC T4 Gb Ex tb IIIC 135°C Db	IECEx ULD 20.0022 Issue 0X					x	x
	EAC Ex	? ?	? ?					x	x
	Segurança INMETRO UL BR	Ex db IIC T4 Gb Ex tb IIIC 135°C Db	UL-BR 21.1250X					x	x
	CCC	Ex d IIC T4 Gb Ex tD A21 IP66/67 T135°C	No: 2021122315114599					x	x

10 Example labels

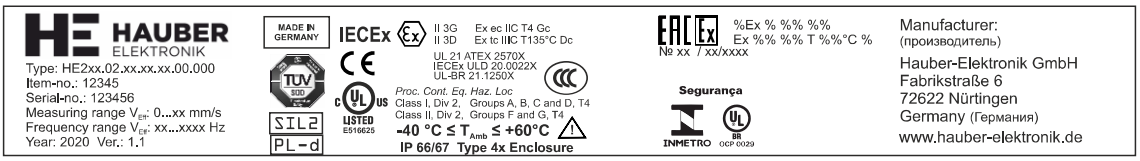
Variant 1 - HE200.00.xx.xx.xx.00.000



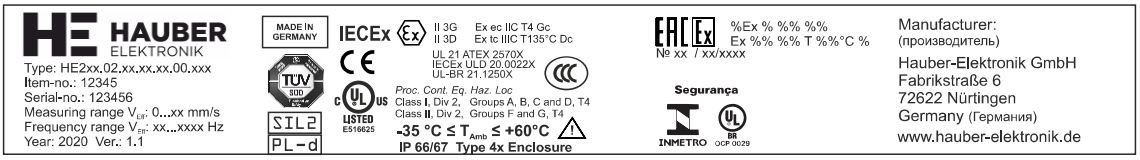
Variant 2 - HE200.00.xx.xx.xx.01.xxx



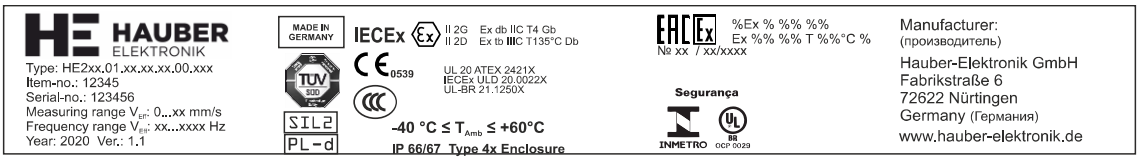
Variant 3 - HE200.02.xx.xx.xx.00.000



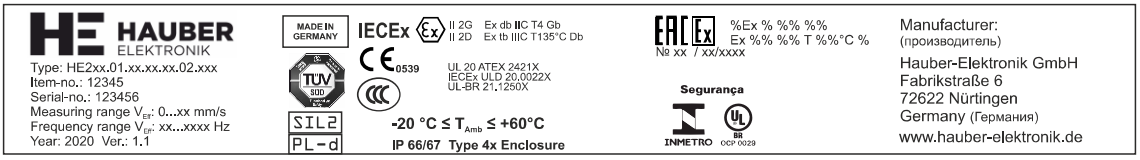
Variant 4 - HE200.02.xx.xx.xx.01.xxx



Variant 5 - HE200.01.xx.xx.xx.00.xxx



Variant 6 - HE200.01.xx.xx.xx.02.xxx



11 Connection

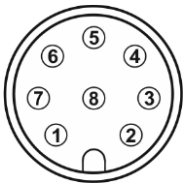
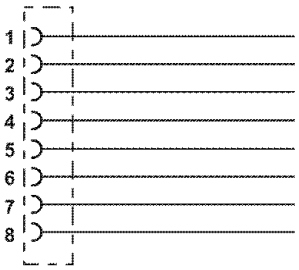
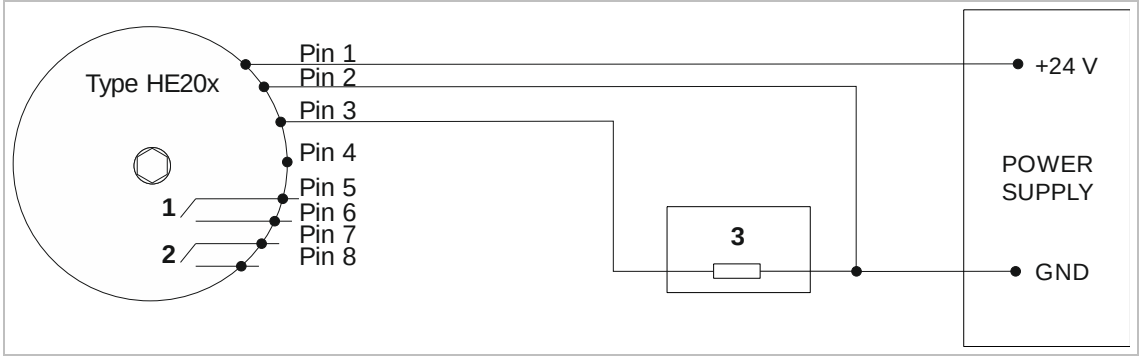
Version:	**M12 connector**		
	Pin 1:		24 V DC
	Pin 2:		GND
	Pin 3:		4-20 mA output signal
	Pin 4:		NC (Not connected)
	Pin 5:		Potential-free switching contact 1 +
	Pin 6:		Potential-free switching contact 1 -
	Pin 7:		Potential-free switching contact 2 +
	Pin 8:		Potential-free switching contact 2 -
Version:	**Integrated cable**		
	Pin 1:	white	24 V DC
	Pin 2:	brown	GND
	Pin 3:	green	4-20 mA output signal
	Pin 4:	yellow	NC (Not connected)
	Pin 5:	grey	Potential-free switching contact 1 +
	Pin 6:	pink	Potential-free switching contact 1 -
	Pin 7:	blue	Potential-free switching contact 2 +
	Pin 8:	red	Potential-free switching contact 2 -
Wiring diagram:			
			

Fig. 1: Wiring diagram

1 Potential-free switching contact 1 (pin 5: + , Pin 6: -)

2 Potential-free switching contact 2 (pin 7: + , Pin 8: -)

3 Evaluation unit

The wiring diagram shows the alarm status or the current status!
Potential-free switching contacts 1 and 2 are open.

12 Assembly and installation

Pay attention to the assembly and installation notes in the operating manual. To do this, select threshold value settings so that the safety function is triggered before any damage can be done to the system.

The sensor must be powered by a SELV power supply in safe operation.

13 Functional description

In an explosive atmosphere the vibration monitoring unit HE200 will only be opened in a de-energized state.

The HE200 type has two limit values Lim1 and LIM2 and the corresponding delay times, which can be adjusted separately. If the defined limit value is exceeded and after the set delay time has expired, the corresponding potential-free switching contact is opened. This can be used to generate a pre-alarm and a main alarm.
A subsequent fall below the limit value is also signalled at potential-free switching contacts 1 and 2, i.e. the respective switching contact automatically closes.
The HE200 type also has an analogue current output. This supplies direct current of 4-20 mA proportional to the vibration amplitude.

13.1 Operating conditions

Operating state	Reading	Switching contacts	LED status
OK	≤ Limit value	Closed	green
WARNING	> Limit value, delay time runs	Closed	green + yellow
ALARM	> Limit value, delay time expired	Open	red
Fail Safe State	0 mA	Open	red + yellow + green
De-energized	0 mA	Open	All LEDs off

Tab. 4: Operating conditions

13.2 Alarm and limit setting

While the sensor is in configuration mode, the safety functions are deactivated.

By pressing the "Save Config" button, the current configuration is displayed by the LEDs around the HEX switches.

The limit values and delay times are calibrated using the respective HEX switch. As soon as a switch position is changed, all LEDs start flashing. Press and hold the "Save Config" button for three seconds to save the configuration. Acceptance of the configuration is signalled by steady lighting up of the LEDs in the selected HEX switch position.

After about five minutes the LEDs turn off automatically.

13.3 Limit values and delay times

The **SET rotary button** has 16 positions, representing the limit value of an alarm. The measuring range of the vibration monitoring unit is divided into 16 linear steps.

In general: $Threshold\ value\ \frac{top\ limit\ of\ measuring\ range}{16} \times SET\ Position$

Example: Limit setting

Measuring range:	0-32 mm/s
SET rotary button Pos.:	8 (9)
Limit value:	16 mm/s (18 mm/s)

SET-Position ↓	**Limit values (mm/s)**								
Measuring range →	**0 – 8 mm/s**	**0 – 10 mm/s**	**0 – 16 mm/s**	**0 – 20 mm/s**	**0 – 25 mm/s**	**0 – 32 mm/s**	**0 – 50 mm/s**	**0 – 64 mm/s**	**0 – 128 mm/s**
0	0.0	0	0	0	0	0	0.00	0	0
1	0.5	0.625	1	1.25	1.563	2	3.13	4	8
2	1.0	1.25	2	2.5	3.125	4	6.25	8	16
3	1.5	1.875	3	3.75	4.688	6	9.38	12	24
4	2.0	2.5	4	5	6.25	8	12.50	16	32
5	2.5	3.125	5	6.25	7.813	10	15.63	20	40
6	3.0	3.75	6	7.5	9.375	12	18.75	24	48
7	3.5	4.375	7	8.75	10.938	14	21.88	28	56
8	4.0	5	8	10	12.5	16	25.00	32	64
9	4.5	5.625	9	11.25	14.063	18	28.13	36	72
10	5.0	6.25	10	12.5	15.625	20	31.25	40	80
11	5.5	6.875	11	13.75	17.188	22	34.38	44	88
12	6.0	7.5	12	15	18.75	24	37.50	48	96
13	6.5	8.125	13	16.25	20.313	26	40.63	52	104
14	7.0	8.75	14	17.5	21.875	28	43.75	56	112
15	7.5	9.375	15	18.75	23.438	30	46.88	60	120

Tab. 5: Limit values for vibration velocities

SET-Position ↓	Limit values (g)					
Measu-ring range →	0-1 g	0-2 g	0-4 g	0-6 g	0-8 g	0-10 g
0	0	0	0	0	0	0
1	0.063	0.125	0.25	0.375	0.5	0.625
2	0.125	0.25	0.5	0.75	1	1.25
3	0.188	0.375	0.75	1.125	1.5	1.875
4	0.25	0.5	1	1.5	2	2.5
5	0.313	0.625	1.25	1.875	2.5	3.125
6	0.375	0.75	1.5	2.25	3	3.75
7	0.438	0.875	1.75	2.625	3.5	4.375
8	0.5	1	2	3	4	5
9	0.563	1.125	2.25	3.375	4.5	5.625
10	0.625	1.25	2.5	3.75	5	6.25
11	0.688	1.375	2.75	4.125	5.5	6.875
12	0.75	1.5	3	4.5	6	7.5
13	0.813	1.625	3.25	4.875	6.5	8.125
14	0.875	1.75	3.5	5.25	7	8.75
15	0.938	1.875	3.75	5.625	7.5	9.375

Tab. 6: Vibration acceleration limit values

Delay times

TIME Position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Delay time (secs)	0	1	2	3	4	5	7.5	10	12.5	15	17.5	20	25	30	45	60

Tab. 7: Delay times

14 Behaviour during operation and when errors occur

The set elements and/or device parameters should not be changed during operation. If set elements and/or device parameters are changed during operation, the operator must ensure the safety of the system! Occurring errors are described in the fault table in the operating manual. If errors are detected, the entire vibration monitoring unit must be taken out of operation and other measures must be taken to keep the process in a safe state. The operating manual describes how to replace the vibration monitoring unit.

15 Self-diagnostic and recurring checks

The sensor has a set of self-diagnostic measures. These are divided into 2 categories:

1. Start-up diagnostic:

These tests are only run in the sensor's initial start-up phase. Among other things, hardware-critical pathways are tested here that cannot be switched off once the device is in operation. One of these critical tests is the diagnostic for the pre-alarm and main alarm switching outputs. In order to ensure the functionality of the switching outputs over the product's service life, the system operator must make sure to cycle the power on the vibration monitoring unit once a year.

2. Cyclical monitoring:

   Cyclical monitoring is fully automated and ensures that all tests are performed and evaluated within 12 hours for a diagnostic coverage of > 90%.

16 Service life

The measuring system has a service life of 10 years.

17 Key indicators related to safety

Failure category	Failure rate (FIT)
Σλ Safe / Fail Safe Detected (λSD)	600
Σλ Dangerous / Fail Dangerous Detected (λDD)	350
Σλ no part	80
Σλ Total	1030
Σλ Dangerous Detected / Fail Dangerous Detected (λDD)	350
Σλ Dangerous Undetected / Fail Dangerous Undetected (λDU)	15

SFF (Type B) SF	94%
SIL	2
Performance Level	D
Category	2
PFD	$\geq 10^{-3} – < 10^{-2}$
PFH	$< 2*10^{-7}$ 1/h With an average expected requirement rate of fewer than 25 times per year
Diagnostic Coverage	>90%

Tab. 8: Failure rates

MTTF	984898hrs = 112.43 years
DC_{avg}	>90% Diagnostic Coverage
$MTTF_d$	2889526hrs = 329.85 years = **HIGH**
CCF	95 (fulfilled)
Response time	200 ms

Tab. 9: Key indicators related to safety according to ISO 13849-1

18 EU declaration of conformity

Declaration of conformity

HAUBER-Elektronik GmbH
Fabrikstraße 6
D-72622 Nürtingen

declares under our sole responsibility that the products listed below that relate to this declaration meet the basic health and safety requirements of the norms and directives below.

Product series

HE200, HE205, HE250, HE250

ATEX Annex

UL International Demko A/S certifies as **Notified Body No. 0539** according to the Directive of the Council of the European Community of 26 February 2014 (2014/34/EU) that the manufacturer maintains a quality assurance system for production that complies with **Annex IV** of this Directive.

Affixed CE marking

CE 0539

Norms and directives

EU Directive	Norms
2014/30/EU	EN 61000-6-7:2015 EN 61000-6-3:2007 + A1:2011 EN55011:2016 + A1:2017
2014/34/EU	IEC 60079-0:2017 + Corr.1:2020 + I-SH01:2019 + I-SH02:2019 IEC 60079-1:2014 + Corr. 1:2018 + I-SH01:2020 IEC 60079-7:2017 IEC 60079-31:2013

Marking and certificates

HE200.02 / HE205.02 / HE250.02 / HE255.02

Marking	Certificate
Ex II 3G Ex ec IIC T4 Gc Ex II 3D Ex tc IIIC 135°C Dc	UL 21 ATEX 2570 X

HE200.01 / HE205.01 / HE250.01 / HE255.01

Marking	Certificate
Ex II 2G Ex db IIC T4 Gb Ex II 2D Ex tb IIIC 135°C Db	UL 20 ATEX 2421 X Rev. 0

Signature

Nürtingen, 03/05/2021

Place and date

T. Bronkal

Tobias Bronkal, Managing Owner